Report for 2005OR64B: Determining Spatial and Temporal Variability of Groundwater Nitrate in the Southern Willamette Valley, OR

Publications

- There are no reported publications resulting from this project.

Report Follows

Determining Spatial and Temporal Variability of Groundwater Nitrate in the Southern Willamette Valley, OR

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EXECUTIVE SUMMARY

The Southern Willamette Valley (SWV) of Oregon has recently been designated a Groundwater Management Area (GWMA) due to concerns over high groundwater nitrate concentrations. As a GWMA, remedial practices must be implemented and groundwater monitoring must occur to determine if and when change occurs. We examined temporal and spatial variability of groundwater nitrate for the SWV with the objective of determining if seasonality exists. Seasonal fluctuations can complicate trend detection in groundwater monitoring, and thus it is important that baseline seasonal data is collected.

We determined if seasonal variability is present in the SWV by creating a monitoring network of 19 wells which we sampled for 15 months. Seasonal fluctuations of several mg/L were observed in nearly all wells sampled. Although network-wide seasonal trends were not statistically significant, our results indicate that the highest concentration months also generally have the highest rainfall, while the lowest concentration months have the least rainfall. Additionally, we found that of the two major hydrogeologic units for the study area (the Willamette Silt and the Willamette Aquifer) have statistically significant differences in concentration and variability. These differences are largely attributable to differences in land use and physical properties of the two units.

A hydrologic model was created to examine nitrate leaching in the SWV and to determine how land use change is likely to affect groundwater nitrate concentrations. Results from the model are largely consistent with observed results and thus it is being used to further analyze several alternative future scenarios. Best Management Practices being examined in the future scenarios include decreases in fertilizer, irrigation, and changes in crop types. Complete results will be available in Glenn Mutti's MS thesis and will also be posted to the web at the PI's website, http://science.orst.edu/~haggertr/WS/.

PROJECT DESCRIPTION & RESULTS

The objectives of this project were to determine if temporal and spatial variability are present in groundwater nitrate in the Southern Willamette Valley (SWV) of Oregon, and to model nitrogen loading and leaching related to land use for the SWV. A brief summary of our findings is included in this report; complete findings will be available in the MS thesis of Glenn Mutti (expected completion date March/April 2006) and will be posted to the web.

The SWV has regionally high groundwater nitrate concentrations (as documented by Eldridge (2003); Aitken et al. (2003); and Vick (2004)) and has been designated a Groundwater Management Area (GWMA) by the Oregon Department of Environmental Quality due to concerns about public health. Though several studies have examined the spatial distribution of groundwater nitrate concentrations, no study has examined monthly fluctuations in concentration for the SWV. Monthly studies examining vadose leachate for the Willamette Valley indicate that a strong seasonal trend is present for nitrate, with high concentration vadose water being purged from the root zone during rainy fall and winter months (Faega 2004, Shelby 1995). In this study we investigated if the seasonal pulse of high concentration vadose water causes temporal fluctuations in groundwater nitrate, filling a major data gap necessary for the design and implementation of a groundwater monitoring network in the SWV.

To determine temporal groundwater nitrate variability, we sampled from a network of 19 wells for 15 months (August 2004 – October 2005). Sample wells were selected from regions identified as significant with regard to spatial distribution, land use, hydrogeologic unit, and expected nitrate concentration (based on previous studies). After potential wells were selected, a well became a sample site if sampling permission was granted and it passed initial quality assurance standards. Quality assurance standards included a negative coliform bacteria test, well depth ≤ 50 ft, screening interval ≤ 15 ft, well log extant, and a drilling date within the last 30 years. Sampling protocols included an approximate purge time of 15 minutes, with samples collected after field parameters stabilized (field parameters collected most months include temperature, pH, conductivity, and dissolved oxygen).

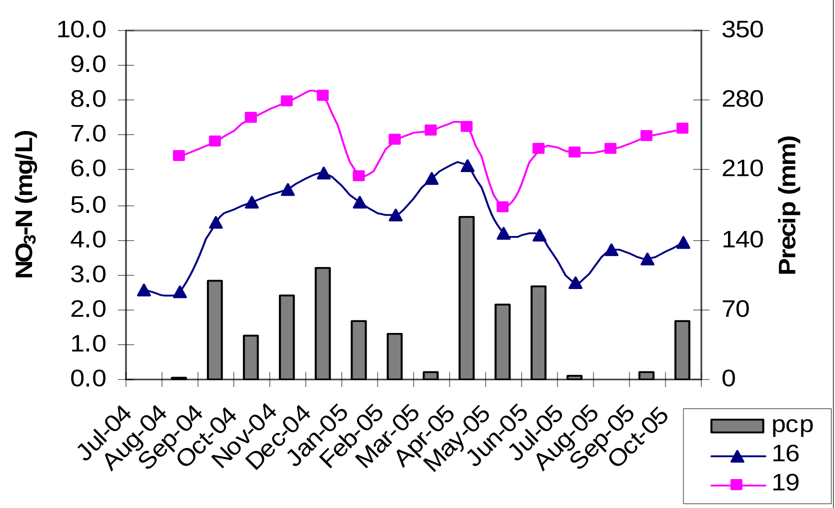

Figure 1: Seasonal fluctuations observed for two wells (16 and 19). Precipitation between sampling events is shown as bars.

Our results indicate that though network-wide seasonal nitrate differences are not statistically significant, seasonal nitrate fluctuations are considerable and generally are influenced by precipitation (see Figure 1). Most wells had higher nitrate

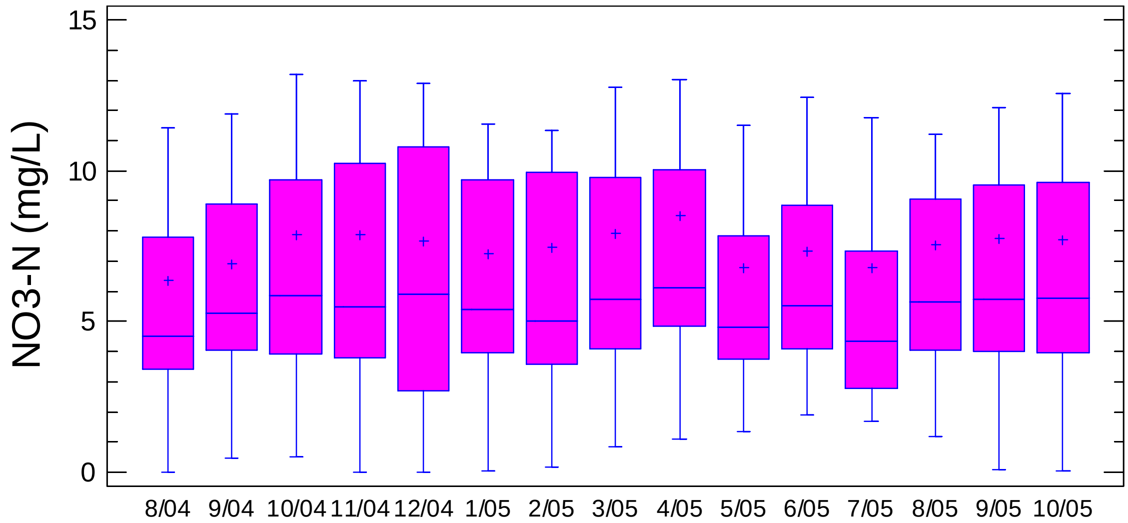

Figure 2: Monthly box and whisker plot for all data collected. "+" indicates the monthly mean values, the box bounds the 25th and 75th data percentiles, and the middle bar is the median. Whiskers extend to the farthest data point within 1.5 times of the box height. Median concentrations did not statistically differ (indicating no seasonality), but concentration fluctuations did generally follow precipitation

concentrations during months with heavy rain. In this study we found that April, the sampling month with the highest rainfall, had the highest nitrate concentrations for most wells. However, since our data were collected in an unusually dry winter, we believe that in an average year, concentrations would be highest in January or December, months that commonly have the highest precipitation. Months with the lowest median concentrations were July and August, which we expect to remain true most years (see Figure 2).

Several other trends were observed, including an apparent increase in groundwater nitrate concentrations with proportional increases in precipitation for months with recharge. Additionally, lower concentrations and temporal variabilites were found to exist in the Willamette Silt hydrogeologic unit, while a scaling effect between a well's median nitrate concentration and its variability was noted. The differences in variabilities are believed to largely be a function of land use, with higher intensity agriculture associated with higher concentrations, variabilities, and areas without the Willamette Silt. Wells having markedly different variabilities imply that different monitoring frequencies may be appropriate for different regions of the GWMA.

Implications of the seasonality observed at individual wells are numerous. From a homeowner's perspective, it is concerning because an annual well test may indicate suitable drinking water, but in reality concentrations may exceed the EPA public health limit (10 mg/L NO_3-N) for several months of a year. From a monitoring perspective, seasonal fluctuations will make long-term trend detection more difficult. Additionally, sample frequencies and dates will need to be well-planned if minimal seasonal noise is desired in the data set. Inferences that can be drawn from higher concentration months generally being high precipitation months is that vadose nitrate flushing has an impact on groundwater nitrate concentrations, and that at the present, average vadose nitrate concentrations are higher than groundwater concentrations. This implies that for groundwater nitrate concentrations to decline, land management practices need to change and the vadose zone will need to be flushed of much of its nitrate. The flushing of the vadose nitrate could take significant time (years to decades) because of the slow rate of diffusion from small soil pores.

Hydrologic modeling of the SWV was successful at showing areas where high leaching was likely to occur. Modeled results (see Figure 3) show that higher leaching generally occurs in areas overlying the exposed extent of the Willamette aquifer. Work continues in examining the impacts of Best Management Practices (BMPs) with present day land use and projected future land use (future land use data generated by Hulse et al. (2002)). BMPs being investigated include decreased fertilizer use, decreased irrigation, and changes in crop type. Finalized results will be available in Mutti's thesis and posted to the web.

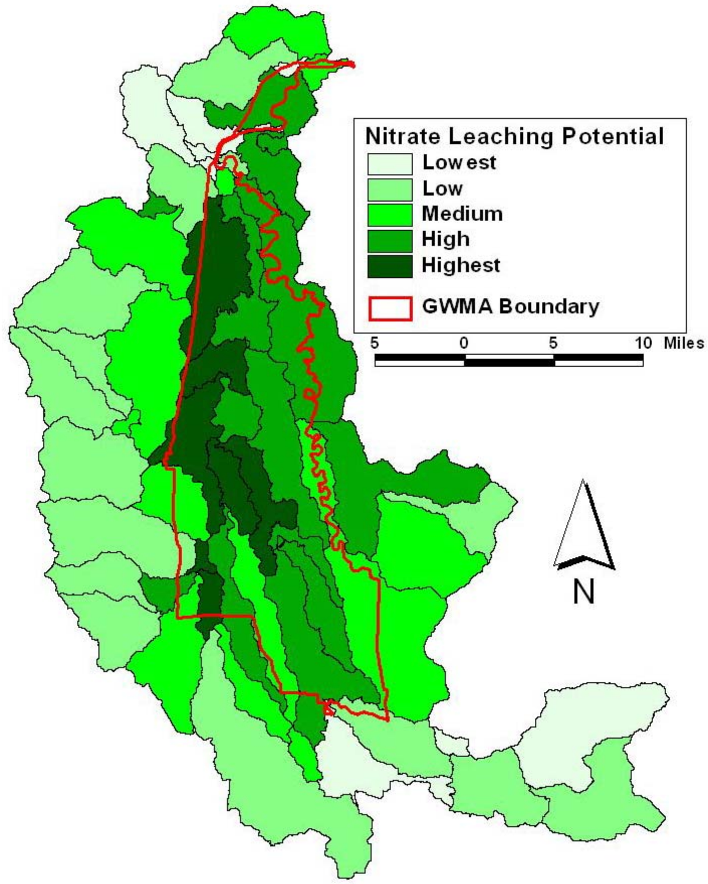

Figure 3: Modeled results showing areas with lower and higher nitrate leaching based on land management and soil types. The darkest green zones mostly overlie regions where the Willamette Aquifer is unconfined and hence more vulnerable to contamination.

The model used in this research is novel because it is the first hydrologic model of the SWV that examines nitrate transport. Additionally, outputs created from this model can be linked to a groundwater model recently developed for the SWV (Craner, 2006). Integrating the leaching data developed from this study with the groundwater model will allow hydrogeologists to gain a deeper understanding of the transport time and likely nitrate source regions for different parts of the aquifer. Combining these models should therefore yield an expected time frame for broad, aquifer-wide concentration changes due to BMP implementation. An expected time frame for regional change is valuable in determining expected monitoring costs and shaping monitoring objectives.

Results from this study will act as a guide for the determining appropriate groundwater monitoring strategies for the GWMA. A presentation on results of this study was well-received by the GWMA committee and is expected to strongly influence the discussion regarding monitoring well installation locations at an upcoming GWMA technical advisory board meeting.

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